Our Case No. 7814/45
UC Tech Ref. UCHI 901

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Milan Mrksich

Serial No. 09/923,760

Filing Date: August 7, 2001

For POLYPEPTIDE IMMOBILIZATION

Examiner Mary E. Ceperley

Group Art Unit No. 1641

DECLARATION UNDER 37 CFR § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Brian K. Kay, declare as follows:

1. My full CV is attached.

2. I am a Senior Biochemist & Group Leader in the Biosciences Division at the Argonne National Laboratory, which is sponsored by the Department of Energy. I have an adjunct appointment as Professor at the University of Chicago. My formal education occurred at the University of Chicago (college) and Yale University (Ph.D., Cell Biology). I did post-doctoral training at the National Institutes of Health in Bethesda, MD. I was on the faculty in the Department of Biology at the University of North Carolina at Chapel Hill for 13 years before moving to the Department of Pharmacology at University of Wisconsin-Madison in 1997. In 2001, I moved to Argonne National Laboratory, which is located 25 miles outside of Chicago, IL.

3. I have been a practitioner of phage display and combinatorial chemistry for the past 15 years. I have authored or co-authored 80 publications in peer-reviewed journals, 31 review articles, and co-edited three books. In the past five years, I have given 46 public talks on phage displayed peptide libraries and their use in mapping protein-protein interactions in the USA, Europe, and Asia. I am listed as an inventor on ten issued patents in the USA, and six issued in Europe, Canada, Australia, and Japan.

4. I have co-authored one publication [Kwon Y, Han Z, Karatan E, Mrksich M, Kay BK. Antibody arrays prepared by cutinase-mediated immobilization on self-assembled monolayers. Anal. Chem. 2004, 76, 5713-5720] with Dr. Mrksich. We are continuing this work in a research project involving peptide and protein arrays.

5. In the paragraphs below, I summarize the inventions described in patent application 09/923,760. To prepare this document, I read the original patent application, the PTO office action, and the law office's response. In addition, I briefly reviewed the literature through PubMed searches circa 2003.

6. The Mrksich and Hodneland patent application teaches a chemical method of immobilizing fusion proteins to a surface so that are accessible for molecular interactions. In one such scheme, immobilization is achieved by attaching a chemical substrate (ligand) for an enzyme to a surface, which when reacted by the enzyme generates a product (reaction product) that forms a covalent bond to the enzyme

(capture polypeptide). Suicide substrates are particularly appropriate ligands, as their cognate enzymes yield reaction products that form a covalent bond somewhere within the active site of the enzyme, thereby inactivating and immobilizing it in a single orientation. Enabling experimental details are given for a variety of enzymes including cutinase, RNAse, and glutathione-S-transferase (GST).

7. In another scenario, the patent outlines the use of a chemical ligand capable of cross-linking to the his-tag of a his-tagged protein. The application teaches that such a ligand can be immobilized on a surface where it can interact with his-tagged proteins in solution. Due to the interaction between the chelated nickel and the multiple histidine residues in the tag, a meta-stable complex would be formed, and the benzoquinone portion of the ligand can then form a covalent bond to a nearby residue, thereby covalently immobilizing the his-tagged protein on the surface.

8. The patent also teaches that protein fusions (of peptides and proteins) can be created by standard molecular biology and chemical ligation techniques. Fusions can be to peptides, proteins, or protein domains. The fusion partner (capture polypeptide) can be an enzyme, such as cutinase, RNAse, and glutathione-S-transferase (and several others listed in a table) or a six-histidine tag. For a person trained in the art of molecular biology and protein engineering, it is clear that many different fusion partners and chemical ligands are possible. In fact, there is utility in having several different options as some peptides and proteins express better in *E. coli* when fused to some

fusion partners than others and, depending on the type of experiment, some chemical ligands may show undesired non-specific sticking.

9. While the patent teaches the use of self-assembly monolayers, with alkanethiols as the preferred form of linker, presumably many other types of surfaces and linkers are possible. For instance, the chemical ligands could be attached directly to a semiconductor chip, plastic, nitrocellulose membrane, or metal through chemical derivatization of such materials or with another type of suitable linker. Regardless of the material and linker choice, the enabling concept is to use a chemical ligand to capture a fusion protein in a covalent manner without any loss of activity or proper conformation of the displayed element. This is currently not achievable with existing chemical cross-linkers, or binding reagents, or simply by passive adsorption.

10. The advantages of this invention are several fold. First, samples are covalently attached to a surface. The application demonstrates that the immobilized GST and cutinase fusion proteins are retained on the surface even in the presence of a strong detergent, sodium dodecyl sulfate, indicating a very strong interaction, such as a covalent bond. (Additional experiments would be necessary to prove that a covalent bond is actually present.) Second, the immobilized are attached in one orientation. In the case of a suicide substrate, the reaction product forms a covalent bond in the active site, thereby inactivating it and immobilizing the captured enzyme molecules in one orientation relative to the surface. Finally, the displayed portion (i.e., peptide or protein) of the fusion protein is readily accessible to molecular interactions. These methods are

technical improvements to the current state-of-the-art of 2003. At the time, scientists typically immobilized proteins by non-specific adsorption to glass or plastic, where the proteins would be randomly arrayed (some active, some inactive) in an imprecise manner. In one publication [Michaud, G.A., Salcius, M., Zhou, F., Bangham, R., Bonin, J., Guo, H., Snyder, M., Predki, P.F., and Schweitzer, B.I. (2003). Analyzing antibody specificity with whole proteome microarrays. Nat. Biotechnol. *21*, 1509-1512] proteins were deposited on a glass slide. This fabrication method will lead to false-negative results due to denaturation of the protein when applied to glass (i.e., road-kill) or lack of accessibility to the epitope due to direct adsorption to the glass surface. In another publication [Zhu, H., Bilgin, M., Bangham, R., Hall, D., Casamayor, A., Bertone, P., Lan, N., Jansen, R., Bidlingmaier, S., Houfek, T., Mitchell, T., Miller, P., Dean, R.A., Gerstein, M., and Snyder, M. (2001). Global analysis of protein activities using proteome chips. Science *293*, 2101-2105] the authors found that "the nickel-coated slides gave superior signals for our particular protein preparations" which were his-tagged proteins. The authors tried this method of capture (spotting proteins onto nickel-coated slides, in which the fusion proteins attach through their six-histidine tags) because they "presumably uniformly orient (them) away from the surface." While correct, one drawback of such a strategy is that the dissociation constant of a his-tagged protein with the nickel chelate is ~ 1 μM, which means that the proteins are bound with the half-life of one second. A more detailed discussion of the advantages of the methods taught by Mrksich and Hodneland can be found in the introduction of a 2004 publication from my laboratory [Kwon, Y., Han, Z., Karatan, E., Mrksich, M., and Kay, B.K. (2004). Antibody arrays

prepared by cutinase-mediated immobilization on self-assembled monolayers. Anal. Chem. 76, 5713-5720].

11. Arrays of such immobilized fusion proteins can be used for a variety of purposes, such as mapping kinase and protease specificities. Arrays of fusion proteins can be generated by a variety of techniques and then incubated with protein kinases or proteases to determine which ones are potential cellular substrates using standard techniques (i.e., isotopic labeling, antibody detection). One could also monitor protein binding to the array using standard techniques such a fluorescence, surface plasmon resonance, and mass spectrometry. In my publication [Kwon, Y., Han, Z., Karatan, E., Mrksich, M., and Kay, B.K. (2004). Antibody arrays prepared by cutinase-mediated immobilization on self-assembled monolayers. Anal. Chem. 76, 5713-5720] we constructed fusions proteins between cutinase and antibody fragments and affinity reagents, immobilized them on a self-assembly monolayer containing a chemical ligand (nitrophenyl phosphonate) for cutinase, and the fusion proteins were covalently immobilized. Most importantly, the immobilized affinity reagents were 100% active and accessible for binding their cognate antigens. In addition, unlike most surfaces we had used in the past such a nitrocellulose membranes and microtiter plate wells, these self-assembly monolayers did not require elimination of non-specific protein binding sites through passivation with excess bulk protein such as bovine serum albumin or milk.

12. I should mention at a personal level that I had a "eureka moment" when I heard Dr. Mrksich first describe his technique for immobilizing protein to a surface with a

suicide substrate (ligand). I had invited him to give a talk in my Department on May 15, 2002, and during his talk I instantly realized that he had solved the problem of how we could immobilize our antibody fragments and affinity reagents on surfaces without denaturing them. We knew from the literature [Butler, J., Ni, L., Joshi, K.S., Suter, M., Rosenberg, B., Chang, J., Brown, W., and Cantarero, L. (1992). The physical and functional behavior of capture antibodies adsorbed on polystyrene. J. Immunol. Meth. *150*, 77-90] and our own experience [Scholle, M.D., Collart, F.R., and Kay, B.K. (2004). *In vivo* biotinylated proteins as targets for phage-display selection experiments. Protein Expr. Purif. 37, 243-252] that many proteins lost their conformation and became denatured (and inactive) when affixed directly to plastic in microtiter plate wells. We started collaborating the following month (according to my calendar), when I made an office visit with Dr. Mrksich at the University of Chicago on June 12, 2002.

13. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-referenced application or any patent issuing thereon.

Date: May 16, 2005 By: Brian K. Kay

Brian K. Kay, Ph.D.

CURRICULUM VITAE

Name: Brian Kenneth Kay

Date and Place of Birth: March 17, 1953 - Fort Monmouth, NJ, USA

Office Address: Division of Biosciences
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439-9989 USA

Telephone: 630-252-3824
Fax: 630-214-0648
Email: bkay@anl.gov

Home Address: 718 S. Washington Street
Hinsdale, IL 60521-4441 USA

Telephone: 630-654-9987
Fax: 630-214-0648
Email: bkkay@mac.com

Education: University of Chicago
Chicago, IL USA
1971-1975: B.A. Biology (with honors) - 1975

Yale University
New Haven, CT USA
1975-1980: Ph.D. Biology - 1980

Research and Training Experience:
Senior Participant and IRG co-leader, Chicago Materials Research Center (MRSEC), June 2004 – present.

Adjunct Professor, Curriculum on Genetics, University of Chicago, April 2003 – present.

Senior Biochemist & Group Leader, Argonne National Laboratory, Argonne, IL, October 2001-present.

Professor, Department of Pharmacology, University of Wisconsin-Madison, July 2000-September 2001.

Associate Director, Biotechnology Center, University of Wisconsin-Madison, WI, March 1999-September 2001.

Molecular Interaction Facilities Director, Biotechnology Center, University of Wisconsin-Madison, WI, March 1999-September 2001.

Associate Professor, Department of Pharmacology, University of Wisconsin-Madison, WI, July 1997-June 2001.

Co-founder, Novalon Pharmaceutical Corporation, Research Triangle Park, NC, May 1996-May 2000.

Sabbatical Fellow, GlaxoWellcome Research Institute, Research Triangle Park, NC, September 1995 - March 1996. In the laboratory of Dr. H. Mario Geysen.

Associate Professor, Department of Biology, University of North Carolina, Chapel Hill, NC, 1991-1997.

Assistant Professor, Department of Biology, University of North Carolina, Chapel Hill, NC, 1984-1991.

Staff Fellow, Laboratory of Molecular Genetics, National Institute of Child Health and Human Development, Bethesda, MD, 1982-1984. In the laboratories of Drs. Keiko Ozato and Igor Dawid.

Postdoctoral Research Fellow, Anna Fuller Research Foundation, National Cancer Institute, Bethesda, MD, 1980-1982. In the laboratory of Dr. Igor Dawid.

Predoctoral Trainee, NIH, Department of Biology, Yale University, New Haven, CT, 1975-1980. In the laboratory of Dr. Joseph Gall.

Societies: American Society for Cell Biology
American Chemical Society
American Society for Pharmacology and Experimental Therapeutics

Offices: Duke University Combinatorial Sciences Center (Board of Directors, 1995-1999
North Carolina Peptide Bond Society (President, 1996-1997)

Peer Reviewed Publications:

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11. Kay, B.K. (1989) Parvalbumin expression in normal and mutant *Xenopus laevis* tadpoles. *Adv. Exp. Med. Biol.* 269, 187-194.

12. Nishikawa, B., Fowlkes, D. and Kay, B.K. (1989) Convenient uses of PCR in analyzing recombinant cDNA clones. *BioTechniques* 7, 730-735.

13. Kay, B.K., Sawhney, R.H. and Wilson, S.H. (1990) Potential for two isoforms of the A1 ribonucleoprotein in *Xenopus laevis*. *Proc. Natl. Acad. Sci. USA* 87, 1367-1371.

14. Evans, J.P., Page, B.A. and Kay, B.K. (1990) Talin and vinculin in oocytes, eggs, and early embryos of *Xenopus laevis*: A developmentally regulated change in distribution. *Dev. Biol.* 137, 403-413.

15. Schwartz, L.M., Koslov, L. and Kay, B.K. (1990) Gene activation is required for developmentally regulated cell death. *Proc. Natl. Acad. Sci. USA* 87, 6594-6598.

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18. Malouf, N.N., MacMahon, D.K., Hainsworth, C.N. and Kay, B.K. (1992) A two-motif isoform of the major calcium channel subunit in skeletal muscle. *Neuron* 8, 899-906.

19. Kay, B.K., Adey, N.B., He, Y-S., Manfredi, J.P., Mataragnon, A.H. and Fowlkes, D.M. (1993) An M13 phage library displaying random 38-amino-acid peptides as a source of novel sequences with affinity to selected targets. *Gene* 128, 59-65.

20. Greig, A., Hirschberg, A., Anderson, P.A.W., Hainsworth, C., Malouf, N.N., Oakeley, A.E. and Kay, B.K. (1994) Alternative splicing of cardiac troponin T in rabbit heart. *Circul. Res.* 74, 41-47.

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28. Ikegaki, N., Tang, X.X., Kay, B.K. and Kennett, R.H. (1996) Identification of an epitope recognized by an anti-c-myc monoclonal antibody that cross-reacts with *E. coli* sigma factor using phage display libraries. *Immunotechnology* 2, 37-46.

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30. Cheng X., Kay B.K. and Juliano R.L. (1996) Identification of a biologically significant DNA-binding peptide motif by use of a random peptide phage display library. *Gene* 171, 1-8.

31. Sahu, A., Kay, B.K. and Lambris, J.D. (1996) Inhibition of human complement by a C3-binding peptide isolated from a phage-displayed random peptide library. *J. Immunol.* 157, 884-891.

32. Pierce, H.H., Adey, N.B. and Kay, B.K. (1996) Identification of cyclized calmodulin antagonists from a phage display random peptide library. *Mol. Diversity* 1, 259-265.

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71. Hussain N.K., Yamabhai, M., Bhakarm A.L., Metzler, M., Ferguson, S.S., Hayden, M.R., McPherson, P.S., and Kay, B.K. (2003) A role for epsin N-terminal homology/AP180 N-terminal homology (ENTH/ANTH) domains in tubulin binding. *J. Biol. Chem.* 278, 28823-28830.

72. Wasiak, S., Denisov, A.Y., Han, Z., Leventis, P.A., de Heuvel, E., Boulianne, G.L., Kay, B.K., Gehring, K., and McPherson, P.S. (2003). Characterization of a gamma-adaptin ear-binding motif in enthoprotin. *FEBS Lett.* 555, 437-442.

73. Han, Z., Karatan, E., Scholle, M.D., McCafferty, J., and Kay, B.K. (2004) Accelerated analysis of phage-display output with alkaline phosphatase fusions. *Comb. Chem. High Throughput Screen.* 7, 55-62.

74. Karatan, E., Merguerian, M., Han, Z., Scholle, M.D., Koide, S., and Kay, B.K. (2004). Molecular recognition properties of FN3 monobodies that bind the Src SH3 domain. *Chem. Biol.* 11, 835-844.

75. Scholle, M.D., Collart, F.R., and Kay, B.K. (2004) *In vivo* biotinylated proteins as targets for phage display selection experiments. *Protein Expr. Purif.* 37, 243-252

76. Kwon, Y., Han, Z., Karatan, E., Mrksich, M., and Kay B.K. (2004) Antibody arrays prepared by cutinase-mediated immobilization on self-assembled monolayers. *Anal. Chem.* 76, 5713-5720.

77. Jin, T-G., Kurakin, A., Behnaga, N., Abe, K., Mohseni, M., Sandra, F., Song, K., Kay, B.K., and Khosravi-Far, R. (2004) FADD-independent recruitment of c-FLIPL to Death Receptor. *J. Biol. Chem.* 279, 55594-55601.

78. Chuman, Y., Üren, A. Ellis, J., Lengel, C., Wolf, V., Kay, B.K. and Rubin, J.S. (in press) Identification of a binding motif for secreted frizzled-related protein-1 by phage display. *Peptides*

79. Chung, S.H., Hoffman, A., Bader, S.D., Chen, L., Liu, C., Kay, B.K., and Makowski, L. (in press). Biological sensors based on Brownian relaxation of magnetic nanoparticles. *Appl. Physics Lett.*

80. Scholle, M.D., Kehoe, J.W., and Kay, B.K. (in press) Efficient construction of a large collection of phage-displayed combinatorial peptide libraries. Comb. Chem. High Throughput Screen.

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Book Chapters and Invited Reviews:

1. Dawid, I.B., Kay, B.K. and Sargent, T.S. (1983) Gene expression during *Xenopus laevis* development. In: "Gene Structure and Regulation in Development" (Subtelny, S. and Kafatos, F.C., eds.) Liss, Inc., New York, pp. 171-182.

2. Winkles, J., Jamrich, M., Jonas, E., Kay, B.K., Miyatani, S., Sargent, T. and Dawid, I.B. (1984) Gene regulation during early embryo development of *Xenopus laevis. UCLA Molecular Biology Symposium* 19, 93-108.

3. Peng, H.B., Chen, Q., Rochlin, W.M., Zhu, D. and Kay, B.K. (1988) Mechanisms of neuromuscular junction development studied in tissue culture. In: "Developmental Neurobiology of the Frog" (Pollack, E.D. and Bibb, H., eds.) Alan Liss, Co., New York, pp. 103-109.

4. Kay, B.K., Evans, J.P., Raff, E.C., Stephenson, E.C., King, M.L., Gard, D.L., Klymkowsky, M.W., Elinson, R.P., Holy, J.M. and Strome, S. (1991) The cytoskeletons of gametes, eggs and early embryos. In: "Cell-Cell Interactions in Early Development" (Gerhart, J.C., ed.), Wiley-Liss, Inc., New York, pp. 297-319.

5. Evans, J.P. and Kay, B.K. (1991) Manual and biochemical fractionation of *Xenopus* oocytes. In: "*Xenopus laevis*: Practical Uses in Cell and Molecular Biology," *Methods in Cell Biology*, Vol. 36, (Kay, B.K. and Peng, H.B., eds.), Academic Press, New York, pp. 129-144.

6. Kay, B.K. (1991) Injection of oocytes and embryos. In: "*Xenopus laevis*: Practical Uses in Cell and Molecular Biology," *Methods in Cell Biology*, Vol. 36, (Kay, B.K. and Peng, H.B., eds.), Academic Press, New York, pp. 653-659.

7. Kay, B.K. (1992) Readings in developmental biology. University of North Carolina at Chapel Hill. Howard Hughes Minority Program in Molecular Biology Manual.

8. Kay, B.K. (1995) Biologically-displayed random peptides as reagents in mapping protein-protein interactions. *Persp. Drug Discov. Design* 2, 251-268.

9. Kay, B.K. and Paul, J.I. (1996) High-throughput screening strategies to identify inhibitors of protein-protein interactions. *Molecular Diversity* 1, 139-140.

10. Armstrong, N., Adey, N.B., McConnell, S.J. and Kay, B.K. (1996) Vectors for phage display. In "Phage Display of Peptides and Proteins: A Laboratory Manual" (Kay, B.K., Winter, J. and McCafferty, J., eds.), Academic Press, San Diego, pp. 35-53.

11. Rider, J.E., Sparks, A.B., Adey, N.B. and Kay, B.K. (1996) Microbiological methods. In "Phage Display of Peptides and Proteins: A Laboratory Manual" (Kay, B.K., Winter, J., and McCafferty, J., eds.), Academic Press, San Diego, pp. 55-65.

12. Adey, N.B., Sparks, A.B., Beasley, J. and Kay, B.K. (1996) Construction of random peptide libraries in bacteriophage M13. In "Phage Display of Peptides and Proteins: A Laboratory Manual" (Kay, B.K., Winter, J. and McCafferty, J., eds.), Academic Press, San Diego, pp. 67-78.

13. Sparks A.B., Adey, N.B., Cwirla, S. and Kay, B.K. (1996) Screening phage-displayed random peptide libraries. In "Phage Display of Peptides and Proteins: A Laboratory Manual" (Kay, B.K., Winter, J. and McCafferty, J., eds.), Academic Press, San Diego, pp. 227-253.

14. Kay, B.K. (1997) Review of R. Cortese, Combinatorial libraries: synthesis, screening and application potential. deGruyter and Co., Berlin. 1996, Protein Science.

15. Sparks, A.B., Rider, J.E. and Kay, B.K. (1998) Mapping the specificity of SH3 domains with phage-displayed random peptide libraries. In: "Transmembrane

Signalling Protocols" (Bar-Sagi, D., ed.), Humana Press, New Jersey.

16. Kay, B.K., Kurakin, A.V. and Hyde-DeRuyscher, R. (1998) From peptides to drugs via phage display. *Drug Discov. Today* 3, 370-378.

17. Santolini, E., Salcini, A.E., Kay, B.K., Yamabhai, M. and Di Fiore, P.P. (1999) The EH network. *Exp. Cell Res.* 253, 186-209.

18. Abe, K., Kurakin, A., Mohseni-Maybodi, M., Kay, B., and Khosravi-Far, R. (2000). The complexity of TNF-related apoptosis-inducing ligand. *Ann. NY Acad. Sci.* 926, 52-63.

19. Yamabhai, M., and Kay, B.K. (2001). Mapping protein-protein interactions with alkaline phosphatase fusion proteins. *Methods Enzymol.* 33, 88-102.

20. Kay, B.K., Kasanov, J., and Yamabhai, M. (2001). Screening phage-displayed combinatorial peptide libraries. *Methods* 24, 240-246.

21. McPherson, P.S., Kay, B.K., and Hussain, N. (2001) Signaling on the endocytic pathway. *Traffic* 2, 375-384.

22. Kay, B.K. (2001) Mapping protein-protein interactions with combinatorial peptide libr aries. *Comp. Funct. Genomics* 2, 304-306.

23. Rodi, D., Makowski, L., and Kay, B.K. (2002) One from column A and two from column B: the benefits of phage-display in molecular recognitions studies. *Curr. Opin. Chem. Biol.* 6, 92-96.

24. Kay, B.K. and Knight, S.M. (2002) Screening phage-displayed combinatorial peptide libraries for ligands to protein targets. In: "High-throughput techniques for gene cloning and protein function analysis", Weiner, M. and Lu, Q. (eds.). Eaton Publishers, Natick, MA. Pp. 511-519.

25. Kay, B.K. and Castagnoli, L. (2004) "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries". *Current Protocols in Cell Biology.*

26. Kay, B.K., Scholle, M.D., and Stevens, F.J., (2004) EH domains and their ligands. In: *Structure and Function of Modular Protein Domains.* (Cesareni, G., Gimona, M., Sudol, M. Yaffe, M., eds.) Publisher: Wiley-VCH.

27. Kay, B.K. and Kehoe, J.W. (2004) PDZ domains and their ligands. *Chem. Biol.* 11, 423-425.

28. Han, Z., Karatan, E., and Kay, B.K. (in press) Protein Interaction Networks. In: "Phage Display in Biotechnology and Drug Discovery", Sidhu, S.S. (ed). Marcel Dekker, Inc., New York, NY.

29. Karatan, E., Han, Z, and Kay, B.K. (in press) Display Technologies. *Encyclopedia of Molecular Biology and Medicine.*

30. Kriplani, U., and Kay, B.K., (submitted) Peptide ligands of inert surfaces. *Curr. Opin. Biotech.*

31. Kehoe, J.W., and Kay, B.K. (submitted) Research advances in phage-display. *Chem. Rev.*

Books:

Kay, B.K. and Peng, H.B. (1991) "*Xenopus laevis*: Practical Uses in Cell and Molecular Biology," *Methods in Cell Biology*, Vol. 36, Academic Press, New York (34 contributed chapters), 685 pages.

Kay, B.K., Winter, J. and McCafferty, J. (1996) "Phage Display of Peptides and Proteins: A Laboratory Manual," Academic Press, San Diego (18 contributed chapters), 344 pages.

Moos, W.H., Pavia, M.R., Kay, B.K. and Ellington, A.D. (1997) "Annual Reports in Combinatorial Chemistry and Molecular Diversity," ESCOM, Holland, 354 pages.

Patents:

Kay, B.K. and Fowlkes, D.M. (US Patent # 5,498,528) Totally Synthetic Affinity Reagents

Smith, J. and Kay, B.K. (US Patent # 5,596,079) Mimetics of Senescent Cell-Derived Inhibitors of DNA Synthesis

Kay, B.K. and Fowlkes, D.M. (US Patent # 5,625,033) Totally Synthetic Affinity Reagents

Kay, B.K., Fowlkes, D.M., Adey, N.B. and Sparks, A.B. (US Patent # 5,747,334) Random Peptide Library

Kay, B.K. and Fowlkes, D.M. (US Patent # 5,844,076) Totally Synthetic Affinity Reagents

Kay, B.K. and Adey, N.B. (US Patent # 5,852,167) Totally Synthetic Affinity Reagents

Kay, B.K., Fowlkes, D. M., and Pirozzi, G. (US Patent # 6,011,137) Identification and isolation of novel polypeptides having WW domains and methods of using same.

Sparks, A.B., Hoffman, N.B., Fowlkes, D.M., and Kay, B.K., (Australian Patent # 711141) Polypeptides having a functional domain of interest and methods of identifying and using same,

Kay, B.K. and Fowlkes, D.M. (Japanese patent #3,043,407) Totally Synthetic Affinity Reagents.

Kay, B.K. and Fowlkes, D.M. (Canadian patent #2,155,185) Totally Synthetic Affinity Reagents.

Kay, B.K., Sparks, A.B., Thorn, J.M., Quilliam, L, and Der, C.J. (US Patents # 6,303,574; #6,703,482) Src SH3 binding peptides and methods for isolating and using same.

Pirozzi, G., Kay, B.K., and Fowlkes, D. M. (Australian Patent # 733650) Identification and isolation of novel polypeptides having WW domains and methods of using same.

Fowlkes, D.M. and Kay, B.K. (European Patent #0515516) Methods for identifying heterofunctional fustion proteins.

Sparks, A.B., Kay, B.K., Thorn, J.M., Quilliam, L.A., Der, C.J., Fowlkes, D.M., and Rider, J.E. (US Patent #6,432,920) Nck SH3 binding peptides.

Rubin, J., Uren, A., Horwood, M.T., Gillespie, N.J., Kay, B. K. and Weisblum, B. (PCT 02/055547) SFRP and peptide motifs that interact with SFRP and methods of use.

Fowlkes, D.M. Kay, B.K, Frelinger; J.A., and Hyde-DeRuyscher, R.P. (US Patent # 6,617,114) Identification of drug complementary combinatorial libraries

Sparks, A.B., Hoffman, N., Kay, B.K., Fowlkes, D.M., McConnell, S.J. (US Patent #6,709,821) Polypeptides having a functional domain of interest and methods of identifying and using same.

Sparks, A.B., Kay, B.K., Thorn, J.M, Quilliam, L.A., Der, C. J., Fowlkes, D.M, and Rider, J.E. (European Patent #897392) Peptides binding SH3 domain of cortactin and their use.

Funding:

North Carolina Board of Science and Technology, $6,300; 04/01/85-03/31/86, PI
Monoclonal Antibodies to the Cell Surfaces of Embryonic Neural Tubes

American Cancer Society (CD-263), $255,000; 07/01/85-06/30/89, PI
Cell Surface Proteins of *Xenopus* Embryos

American Cancer Society (IN 15-29), $5,125; 11/85-10/86, PI
Parvalbumin and Oncomodulin Expression in *Xenopus* Embryos

University of North Carolina Research Council, $1,500; 04/01/85-03/31/86 and 04/01/87-03/31/88, PI

Analysis of Cell Surface Proteins during the Embryogenesis of *Xenopus laevis;* Molecular Analysis of the Cytoskeletal Proteins, Talin and Vinculin, during Oogenesis and Embryogenesis

University of North Carolina Junior Faculty Development Award, $3,000; 01/01/86-12/31/86

March of Dimes, Basil O'Connor Starter Scholar Award (5-576), $78,000; 09/01/87-06/30/89, PI; Monoclonal Antibodies to Neural Tubes of *Xenopus* Embryos

North Carolina Biotechnology Program (ARIG 881011), $25,000; 06/01/87-12/01/89, PI
Molecular Cloning of Trophic Factors

NIH Biomedical Instrumentation Program, $30,000; 1988, Co-PI
Gene Expression in Frogs and Bacteria

NIH Institutional Basic Science Research Grant, $5,250; 04/01/89-03/31/90, PI
Developmental Regulation of an hnRNP Protein

NIH (R01 HL42250), $161,000; 10/01/88-09/30/91, Co-PI
Developmental Correlates: Contractile and Membrane Proteins

NIH Institutional Basic Science Research Grant, $3,500; 01/01/91-03/31/91, PI
Developmental Regulation of an hnRNP Protein

NIH (R01 HL42250), $210,000; 08/01/91-07/31/95, Co-PI
Developmental Correlates: Contractile and Membrane Proteins

Muscular Dystrophy Association, $135,000; 07/01/91-06/30/94, Co-PI
Parvalbumin Expression in *Xenopus* Embryos and Oocytes

Cytogen Corporation, $180,000; 01/01/92-12/31/94, PI
Totally Synthetic Affinity Reagents

North Carolina Biotechnology Center, $210,000; 08/01/92-07/31/93, Co-PI
PhosphorImaging Work Stations

Muscular Dystrophy Association, $45,000; 07/01/94-06/30/95, Co-PI
Mapping Protein-Protein Interactions of Dystrophin

Cytogen Corporation, $260,000; 01/01/95-12/31/96, Co-PI
Totally Synthetic Affinity Reagents

Muscular Dystrophy Association, $88,000; 07/01/95-06/30/96, Co-PI
Mapping Protein-Protein Interactions of Dystrophin

Cytogen Corporation, $17,500; 01/01/96-12/31/96, PI
Screening Combinatorial Chemical Libraries for Src SH3 Antagonists

North Carolina Biotechnology Center, $40,000; 10/01/96-09/30/98, PI
Cell Death Domains and Combinatorial Ligands

Novalon Pharmaceutical Corporation, $152,000; 01/01/97-12/31/97, PI
Molecular Recognition of Viral and Cellular Proteins

Abbott Laboratories, $6,000; 01/01/97-04/30/97, PI
Mapping Epitopes

University-Industry Relations (UIR), $30,000; 07/01/98-06/30/99, PI
Generation of Phage-Displayed Peptide Libraries

Novalon Pharmaceutical Corporation; $90,375; 01/01/98-12/31/99, PI
Targeting the Destruction of Cellular Proteins

University of Wisconsin Graduate School, $9,950; 07/01/98-06/30/99, PI
Intersectin, a Novel Two EH and Five SH3 Domain Protein

Leukemia Society of America, $324,000; 09/01/98-08/31/01, PI
Design of α-Helical Mimetics that Antagonize Specific Protein-Protein Interactions in Leukemias

Industrial & Economic Development Research (I&EDR), $28,000; 07/01/99-06/30/00, PI;
Constructing a Plant Antiome

University of Wisconsin Comprehensive Cancer Center, $18,000, 01/01/00-12/31/00, PI
Screening Libraries of Natural Products for Inhibitors

NIH, Small Business Technology Transfer Program, $1,365,598; 8/1/01-7/31/03, PI
Development of a Maskless Array Synthesizer

NIH, $18,000,000, Co-PI with Drs. John Markley, George Phillips, Ivan Rayment, and Michae Sussman; 11/1/01-10/31/06
The Three-dimensional Structure of *Arabidopis thaliana* Proteins

Laboratory Division Research Development, DOE, $3,000,000; 10/1/01-9/30/05, PI
Functional Genomics Initiative

The Amyotrophic Lateral Sclerosis Association, $70,000; 8/1/03-7/31/03, co-PI with Dr. Rayr Roos
Studies of Fv single chain antibodies in FALS

Defense Advanced Research Projects Agency (DARPA), #8C67400, $250,000; 03/01/03-09/30/05, PI: Dr. Liaohai Chen
Sensors based on resonant oscillation of magnetic phage with high affinity and specificity for target molecules

NIH, $250,000; 03/01/03-9/31/05, Co-PI with Drs. Liaohai Chen, Heinrich Jaeger, and Rong Wang

Nanotechnology for systems biology of neural stem cells

NIH RCE, 1 U54 AI057153-01, $90,000; 10/1/03-9/30/04
PI: Olaf Schneewind, Co-PIs: Andrzej Joachimiak, Natalia Maltsev, Dominique Missiakis, and Phil Hanna
Therapeutic inhibition of *Bacillus anthracis* pathogenesis

ANL Laboratory Directed Research and Development Program, #2004-240, $100,000; 10/01/04-9/30/05, Co-PI: Carol Giometti
Phage-display and Cardiac Proteomics

Office of Naval Research, Grant #N00014-04-1-0796, $40,000; 9/6/04-4/30/07, PI: Dr. Terry Vanden Hoek, Co-PI with Dr. Lance Becker
Proteomic development of molecular vital signs: mapping a mitochondrial injury severity score to triage and guide resuscitation of hemorrhagic shock

Teaching:

Biology 52: Cell and Developmental Biology, 150-200 students, Spring Semester, with Drs. E. Salmon, J. Pringle, or E. Young, 1984-1997

Biology 98: Independent Research, three students per semester, 1984-1997

Biology 99: Undergraduate Biology Honors Research, 25-30 students, Spring Semester, 1990-1997

Biology 167: Advanced Cell Biology, 30-45 students, Fall Semester, with Drs. S. Matson, W. Marzluff, or R. Quatrano, 1985-1997

Guest Lectures in University of North Carolina at Chapel Hill Medical School (Embryology, The Cell Biology of Growth Factors, Developmental Neurobiology)

Biology 251: Graduate Students Research Presentations, ~40 students, 1994-1996

Pharmacy, Medicinal Chemistry, three lectures per semester, 1996-1997

Pharmacology 875 section 2: Combinatorial Chemistry and Drug Discovery, ~10 students, Spring 1998 and 1999; 38 in Spring 2000; 21 in 2001

Pharmacology 710: Nuclear and Cytoplasmic Signalling Cascades, 15-24 students, Spring 1998, with Drs. R. Anderson, E. Bresnick, Patricia Keeley, Anna Huttenlocher, and S. Miyamoto

Medical School Pharmacology 727: Component Co-Director, 153 students, Spring 1998 - 2001

Pharmacology 724: Graduate Student Seminars in Molecular and Cellular Pharmacology, 33 students, 1999-2000

Biochemistry 323, Protein Molecular Structure and Function, University of Chicago, 2003

Genetics 380, Genomic and Proteomic Approaches to Biological Questions, University of Chicago, Spring quarters, 2004 and 2005, with Dr. Daphne Preuss, 20 students

Invited Talks:

University of Virginia, Department of Cell Biology and Anatomy, 04/20/86, "Regulation of cell surface proteins during *Xenopus* embryogenesis"

National Institutes of Health (NIEHS), 01/28/88, "Regulated assembly of the oocyte cortex in *Xenopus*"

University of Mississippi Medical Center, Department of Biochemistry, 06/07/88, "Regulated assembly of the plasma membrane and cytoskeleton in *Xenopus* oocytes and embryos"

Woods Hole Marine Biology Laboratory, Physiology Course, 08/05/88, "Regulated assembly of the cortex in *Xenopus* oocytes and embryos"

North Carolina State University, Department of Genetics, 09/13/88, "Genetic regulation of the cortex in *Xenopus* oocytes and embryos"

Bowman Gray Medical School, Department of Anatomy, 11/09/88, "Modulation of a Ca2+-binding protein (parvalbumin) in embryonic frog muscle"

Duke University, Department of Medicine, 01/12/89, "Molecular biology of the parvalbumin gene family in *Xenopus*"

University of North Carolina, Department of Biochemistry, 01/24/89, "Muscle differentiation in *Xenopus* and the role of neural input"

Indiana University, Department of Biology, 02/19/89, "Parvalbumin expression is hard-wired in embryonic skeletal muscles and under neural control in adult *Xenopus* muscles"

University of Zurich, Department of Biochemistry, 09/30/90, "The Parvalbumin gene family the *Xenopus*"

Duke University, Department of Zoology, 10/03/90, "Parvalbumin expression in *Xenopus* embryos and adults"

University of North Carolina at Chapel Hill, Department of Pathology, 10/31/91, "Changes in the membrane-cytoskeleton during the oocyte-to-egg transition in *Xenopus*"

University of North Carolina at Chapel Hill, Curriculum in Neurobiology, 01/16/92, "Neural induction in amphibians"

University of North Carolina at Chapel Hill, Department of Ob/Gyn, 02/19/92, "Maturation promoting factor and amphibian oogenesis"

Bender Co., Vienna, Austria, 08/24/92, "Totally synthetic affinity reagents"

Duke University, Department of Pharmacology, 10/21/92, "Calmodulin and parvalbumin gene regulation in *Xenopus*"

University of North Carolina at Chapel Hill, Curriculum in Genetics, 10/30/92, "Random peptide libraries as new tools in mapping epitopes and generating novel affinity reagents"

Genentech, South San Francisco, 02/04/93, "Random peptide libraries as new tools in mapping epitopes and generating novel affinity reagents"

University of North Carolina at Chapel Hill, Department of Chemistry, 02/24/93, "Phage display of random peptides for mapping epitopes and discovering affinity reagents"

Glaxo, Department of Protein Chemistry, 02/25/93, "Phage display of random peptides for mapping epitopes and discovering affinity reagents"

University of Pennsylvania, Department of Biochemistry, 03/16/93, "Phage display of random peptides for mapping epitopes and discovering affinity reagents"

National Institutes of Health, FDA, 05/07/93, "Phage display of random peptides for mapping epitopes and discovering affinity reagents"

University of Virginia, Graduate student invitee, Department of Cell Biology and Anatomy, 05/19/93, "Changes in the cortical cytoskeleton during the oocyte-to-egg transition in *Xenopus*"

University of Pisa, Pisa, Italy, Department of Biochemistry, 10/01/93, "Phage display of random peptides for mapping epitopes of autoimmune antibodies and discovering affinity reagents for cytosolic target proteins"

DuPont Merck Pharmaceutical Co., Wilmington, DE, Department of Structural Biology, 11/12/93, "Mapping protein-protein interactions with random peptide libraries"

National Research Council, Ottawa, Ontario, Canada, Institute for Biological Sciences, 01/13/94, "Mapping protein-protein interactions with random peptide libraries"

University of North Carolina at Greensboro, Department of Biology, 04/06/94, "Mapping protein-protein interactions with random peptide libraries"

Glaxo, Cell Biology Division, 09/16/94, "Mapping protein-protein interactions with random peptide libraries"

International Business Conferences, Epitope Mapping, San Diego, 09/21/94, "Mapping the epitopes of autoimmune lupus antibodies with phage-displayed random peptide libraries"

University of North Carolina at Chapel Hill, Department of Cell Biology and Anatomy, 10/05/94, "Mapping protein-protein interactions with random peptide libraries"

Burroughs Welcome Co, Division of Cell Biology, 11/17/94, "Target validation and phage-display random peptide libraries"

International Business Conferences, Chemical and Biomolecular Diversity, San Diego, 12/14/94, "Mapping protein-protein interactions with phage-displayed random peptide libraries"

American Association for Cancer Research, Toronto, Canada, 03/20/95, "Identification of peptide ligands for the Src SH3 domain using phage-displayed random peptide libraries"

The Peptide Bond, North Carolina Biotechnology Center, 05/02/95, "Mapping protein-protein interactions with random peptide libraries"

International Business Conferences, High Throughput Screening and Automation for Drug Discovery, San Francisco, CA, 06/27/95, "Mapping protein-protein interactions with random peptide libraries"

International Business Conferences (IBC), High-Throughput Screening Strategies to Identify Inhibitors of Protein-Protein Interactions, San Francisco, CA, 08/17/95, "Mapping protein-protein interactions of signal transduction proteins with phage-displayed random peptide libraries"

North Carolina State University, Genetics Department, 09/11/95, "Mapping protein-protein interactions with phage-displayed random peptide libraries"

Biomedical Engineering Society, Boston, MA, 10/06/95, "SH3 domains and peptide

ligands"

American Chemical Society Satellite Teleconference, Washington, D.C., 10/11/95, "Biological combinatorial peptide libraries"

University of North Carolina at Chapel Hill Biotechnology Weekend, 10/14/95, "How an academic scientist became a biotechnologist"

University of North Carolina at Chapel Hill, Department of Pharmacology, 10/24/95, "SH3 domains and peptide ligands"

National Institutes of Health, Phage Display Workshop, 10/27/95, "Mapping the specificity of SH3 domains with phage-displayed random peptide libraries"

Duke University, 9th Annual Cell and Molecular Biology Symposium, 10/28/95, "Phage display and protein domains"

Eisai London Research Laboratories, University College, London, 11/29/95, "SH3 domains and peptide ligands"

International Conference on Combinatorial Library Methods for Basic Research and Drug Discovery, Tucson, AZ, 12/02/95, "SH3 domains and peptide ligands"

Miami Winter Symposium, Ft. Lauderdale, FL, 02/12/96, "SH3 domains and peptide ligands"

Johns Hopkins School of Medicine, Oncology Center, Baltimore, MD, 03/11/96, "SH3 domains and combinatorial peptide ligands"

Eastern Carolina University, Department of Cell Biology and Anatomy, Greenville, NC, 03/22/96, "SH3 domains and combinatorial peptide ligands"

Affymax Research Institute, Palo Alto, CA, 05/15/96, "SH3 domains and peptide ligands"

Vanderbilt University, Department of Molecular Biology, Nashville, TN, 06/27/96, "Mapping protein-protein interactions with phage-displayed random peptide libraries: A case study of SH3 domains"

DuPont Merck Pharmaceutical Institute, Wilmington, DE, 07/24/96, "SH3 domains, combinatorial peptide libraries, and drug discovery"

Fred Hutchinson Cancer Research Center, Seattle, WA, 08/06/96, "SH3 domains, combinatorial peptide libraries, and gene discovery"

European Molecular Biology Laboratories, Heidelberg, Germany, 09/06/96, "SH3 domains, combinatorial peptide libraries, and gene discovery"

International Symposium on Antibody Technology in Health and Environment, National Research Centre for Biotechnology, Braunschweig, Germany, 09/09/96, "SH3 domains and combinatorial peptide ligands"

European Institute for Oncology, Milan, Italy, 09/13/96, "SH3 domains, combinatorial peptide libraries, and gene discovery"

IBC, Molecular Diversity and Combinatorial Chemistry Workshop, San Diego, CA, 10/28/96, "Molecular recognition studies with phage-displayed combinatorial peptide libraries"

Torrey Pines Institute for Molecular Studies, La Jolla, CA, 10/29/96, "SH3 domains, combinatorial peptide libraries, and gene discovery"

University of Wisconsin, Program in Biotechnology, Madison, WI, 12/18/96, "SH3 domains and phage-displayed random peptides: Molecular recognition studies with combinatorial ligands"

University of Wisconsin, Department of Pharmacology, Madison, WI, 01/22/97, "Molecular recognition studies with combinatorial ligands"

IBC, Display Technologies, Speaker and Chair, Lake Tahoe, NV, 02/10-11/97, "Cloning novel genes with phage-displayed peptide ligands"

Cambridge Healthtech, Molecular Evolution, Boston, MA, 04/25/97, "Cloning novel genes with phage-displayed peptide ligands"

European Phage Club Meeting, Smolenice, Slovakia, 05/22/97, "Cloning novel genes with phage-displayed peptide ligands"

American Society for Biochemistry and Molecular Biology, San Francisco, CA, 08/27/97, "Mapping protein-protein interactions by phage-display"

British Biochemical Society, 09/05/97, Galway, Ireland, "Defining the specificity of SH3 domains with phage-displayed peptides"

5th International Workshop on the Molecular and Cell Biology of Autoantibodies and Autoimmunity, Chapel Hill, NC, 09/21/97, "Phage display libraries for molecular dissection"

Leukemia Society of America, Houston, TX, 10/20/97, "Defining the specificity of SH3 domains with phage-displayed combinatorial peptides"

University of Wisconsin-Madison: "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries," Department of Bacteriology (10/02/98);

"Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries," Pharmacy (12/05/97); "Defining the specificity of protein interaction modules with phage-displayed combinatorial peptides," McArdle Laboratory Colloquium (02/24/98); "From peptides to drugs via phage display," Program in Biotechnology (03/02/98); "Protein-protein interactions as molecular therapeutic opportunities," Cancer Center (11/05/98); "Phage-display of combinatorial peptides", Workshop on Emerging Techniques in Screening and Imaging Sciences (10/19/00); "The roles of the scaffold protein, intersectin, in endocytosis and signal transduction", Frontiers of Pharmacology seminar series (9/19/00)

Duke University, Department of Cell Biology, Durham, NC, 04/09/98, "Defining the specificity of protein-interaction modules with phage-displayed combinatorial peptides"

ASBMB National Meeting, Washington, D.C., 05/19/98, "Defining the specificity of protein-interaction modules with phage-displayed combinatorial peptides"

EpScoR Meeting, University of North Dakota, Grand Forks, ND, 05/30/98, "Defining the specificity of protein-interaction modules with phage-displayed combinatorial peptides"

12th Annual Protein Society Meeting, San Diego, CA, 07/28/98, "Using phage-displayed combinatorial peptides to define the specificity of protein interaction modules"

Wayne State University, Department of Biology, Detroit, MI, 10/06/98, "Using phage-displayed combinatorial peptides to define the specificity of protein interaction modules"

2nd International Conference on Combinatorial Library Methods for Basic Research and Drug Discovery, Tucson, AZ, 01/10/99, "Convergent evolution with combinatorial peptide ligands"

90th Annual Meeting, American Association of Cancer Researchers, Philadelphia, 04/10/99, "Mapping protein-protein interactions with phage-display combinatorial peptides"

University of Kentucky, Department of Biochemistry, Lexington, KY, 05/12/99, "Defining the specificity of protein interaction modules"

3rd International Meeting on Phage Technology, Montpellier, France, 05/26/99,"Convergent evolution with combinatorial peptides"

Third Wave Technologies, Madison, WI, 06/18/99, "Mapping protein-protein interactions with phage-display combinatorial peptides"

University of Rome, Department of Biology, Italy, 06/30/99,"The role of EH domain containing proteins and their ligands in endocytosis in yeast and man"

Montreal Neurological Institute, McGill University, Montreal, Canada, 09/21/99,

"Dissecting protein-protein interactions in endocytosis with combinatorial peptides"

Mt. Sinai Medical Center, Department of Biochemistry and Molecular Biology, New York City, NY, 10/14/99, "Dissecting protein-protein interactions in endocytosis with combinatorial peptides"

University of Colorado Health Sciences Center, Department of Pharmacology, Denver, CO, 11/02/99, "Dissecting protein-protein interactions in endocytosis with combinatorial peptides"

Promega, 7/26/00, "Phage-display"

Leukemia & Lymphoma Society, Washington, D.C., 9/13/00, "Developing inhibitors of the DM2-p53 protein-protein interaction"

Medical University of South Carolina, Department of Pharmacology, 10/16/00, "The roles of the scaffold protein, intersectin, in endocytosis and signal transduction"

Pohang University, Pohang, South Korea, 12/7/00, "Roles for the scaffold protein, intersectin, in endocytosis and signal transduction"

Korean Peptide Symposium, Pohang, South Korea, 12/8/00, "Phage-display of combinatorial peptides"

NCI-Developmental Therapeutics Program Conference, Madison, WI, 3/5/01, "Combinatorial peptides in drug discovery"

Structural Bioinformatics, Inc., San Diego, CA, 3/15/01, "From peptides to drugs via phage-display"

National Institutes of Health, Bethesda, MD, 4/11/01, "The role of the adaptor protein, intersectin, in endocytosis and signal transduction"

European Science Foundation, Proteomics Workshop, Rome, Italy 5/11/01, "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries"

Argonne National Laboratories, Argonne, Il 5/25/01, "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries"

Pharmacopiea, Inc., Princeton, NJ, 6/12/01, "From Peptides to Drug Leads via Phage-display"

Xencor, Inc., Monrovia, CA, 6/21/01, "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries"

Aventa Biosciences, La Jolla, CA, 6/28/01, "Mapping protein-protein interactions with

phage-displayed combinatorial peptide libraries"

University of Illinois at Urbana-Champaign, IL, 9/26/01, "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries"

University of Chicago, Hematology/Oncology Section, Chicago, IL 2/11/02, "Mapping protein-protein interactions by phage-display"

University of Virginia, Chemistry Department, Charlottesville, VA, 4/3/02, "Mapping protein-protein interactions with phage-displayed combinatorial peptide libraries"

University of Iowa, Biology Department, Iowa City, IA, 4/12/02, "Mapping protein-protein interactions with combinatorial peptide libraries"

Cambridge Healthtech Institute, Boston, MA, 4/22/02, "Mapping protein-protein interactions with combinatorial peptide libraries"

National Institute of Aging, Baltimore, MD, 5/5/02, "Mapping protein-protein interactions with combinatorial peptide libraries"

High-throughput Screening for Drug Discovery, Marcus Evans, Boston, MA, 7/19/02, "Accelerating drug discovery with peptide ligands from phage-displayed combinatorial peptide libraries"

University of Illinois at Chicago, Department of Medicinal Chemistry & Pharmacognosy, Chicago, IL, 10/4/02, "Drug discovery with peptide ligands from phage-displayed combinatorial peptide libraries"

International Phage Display Meeting, Vancouver, British Columbia, Canada, 1/22/03, "SH3 domain-mediated protein-protein interactions"

University of Illinois at Chicago Campus, Bioengineering Department, 2/7/03, "Applications of phage-display in proteomics and drug discovery"

University of Chicago, Chicago, IL, 2/27/03, "Generating designer affinity reagents by phage-display"

Centocor, Inc., Malvern, PA, 3/7/03, "Generating designer affinity reagents by phage-display"

IBC Meeting, Directed Protein Evolution, San Francisco, CA, 3/25/03, "Combinatorial peptide libraries for and inhibiting mapping protein-protein interactions"

IV Congresso Internacional De Quimica, Tecnologica De Monterrey, Mexico, 3/28/03, "Applications of phage-display in proteomics and drug discovery"

11th International Conference on Microbial Genomes, Durham, NC, 10/2/03, "Peptide ligands"

DuPont Experimental Research Station, Wilmington, DE, 11/7/03, "Generating designer affinity reagents by phage-display"

Brookhaven National Laboratory, Upton, NY, 12/18/03, "Designer affinity reagents"

University of Illinois at Chicago Campus, Department of Pharmacology, 1/14/04, "Generating affinity reagents by phage-display"

University of Chicago, The James Franck Institute, 3/2/04, "Generating affinity reagents by phage-display"

Emory University, Department of Pharmacology, 4/6/04, "Generating affinity reagents by phage-display"

University of Connecticut Health Center, Department of Genetics & Development, 4/15/04, "Generating affinity reagents by phage-display"

Chicago Biomedical Community, UIC, 4/17/04, "Generating affinity reagents by phage-display"

Brookhaven National Laboratory, Upton, NY, 12/19/03, "Designer affinity reagents"

University of Illinois at Chicago, Department of Pharmacology, 1/14/04, "Designer affinity reagents"

University of Chicago, The James Franck Institute, 3/2/04, "Designer affinity reagents"

University of Connecticut Health Sciences Center, Dept. of Biochemistry, 4/15/04, "Designer affinity reagents"

Chicago Biomedical Community, Proteomics Symposium, UIC, 4/17/04, "Designer affinity reagents"

Rosalind Franklin University of Medical Sciences, Department of Biochemistry, 10/14/04, "Designer affinity reagents"

Northern Illinois University, Department of Biology, 10/15/04, "Designer affinity reagents"

Central States Universities Conference on Graduate, Student Research in Nano-science and Technology, ANL, 11/5/04, "Combinatorial approaches to nanotechnology"

Oak Ridge National Laboratory, Life Sciences Division, 12/15/04, "Generating affinity reagents by phage-display"

American Chemical Society 229th Annual Meeting, San Diego, CA, 3/17/05, "High-throughput generations of affinity reagents" and "Genome-derived reagents"

University of Illinois at Chicago, 4/25/05, "Designer affinity reagents".

Meeting and Session Organizer:

Society for Developmental Biology (Georgetown University), 06/27/90, Mini-Symposium Organizer with Janice Evans: *The Cytoskeleton in Eggs and Embryos*

Society for Developmental Biology, Southeastern Regional Meeting (University of North Carolina at Chapel Hill), 05/91, 33rd Annual Meeting, Co-Organized with Ralph Quatrano

Workshop, American Society for Cell Biologists Meeting (Denver, CO), 11/16/92, Organizer: *Phage and Plasmid Display of Proteins and Peptides*

Society for Developmental Biology (University of Georgia), 05/16/93, Mini-Symposium Organizer: *Early Steps in Development*

Fordham Hall Dedication Symposium (UNC-CH) 04/13/94, Co-Organized with Dr. Bill Marzluff

Molecular Diversity Symposium (North Carolina Biotechnology Center), 06/04/94, Co-Organized with Mario Geysen, Marshall Edgell, Mike Green, Fred Hassman, and Sharon Campbell-Burke

Epitope: Identification, Mapping, and Mimetics (San Diego, CA), 09/21-24/94, IBC Meeting, Co-Organized with Richard Houghten

Chemical and Biomolecular Diversity, (San Diego, CA), 12/14-16/94, IBC Meeting, Organizer

Society for Developmental Biology (William and Mary College), 05/28/95, Mini-Symposium Organizer: *The Cytoskeleton and Cell Adhesion*

ASBMB National Meeting (Washington, D.C.) 05/17/98, Session Organizer: *Combinatorics*

Promega Biotechnology Course, 08/05/98, Combinatorial Peptides and Phage-Display

2nd International Conference on Combinatorial Library Methods for Basic Research and Drug Discovery, Tucson, AZ, 01/10-12/99, Program Committee with Drs. Kevin Burgess, Jack Keene, and Michal Lebl

2nd International Conference on Combinatorial Library Methods for Basic Research and Drug Discovery, Tucson, AZ, 01/10-12/99, Co-organized with Dr. Michal Lebl

Affinity Reagents Workshop, Argonne National Laboratory, Argonne, IL, 2/26/03, Organizer

Macromolecular Interactions Workshop, Wisconsin Symposium II: From DNA to Molecular Medicine, Madison, WI, 5/21/03, Co-organizer and speaker

Current Techniques in Protein and Genetic Engineering, Madison, WI, 8//5-9/03, co-teacher

Session co-chair & presenter, DOE Roadmap meeting: Genomic derived Reagents, Washington, DC, 6/14-16/04

Session co-chair & presenter, American Chemical Society 229th Annual Meeting, San Diego, CA, 3/14-17/05

Course Director:

North Carolina Biotechnology Workshop, University of North Carolina, 11/04/90-11/19/90, *Oocyte Injections and Gene Expression*

North Carolina Biotechnology Workshop, University of North Carolina, 05/14/95-05/26/95, *Random Peptide Libraries*

North Carolina Biotechnology Workshop, University of North Carolina, 06/21/97-06/29/97, Co-Directed with Drs. Mario Geysen and Jack Keene, *Combinatorial Libraries: Theory and Screening*, 16 students

UW-Madison Biotechnology Center, 08/17/98-08/21/98, *Screening Phage-Display Libraries*, 16 students

Committee Memberships at UNC:

Undergraduate Affairs Committee
Departmental Long Range Planning Committee
Developmental Biology Task Force Committee
Developmental Biology Campus Seminar Series
Biology Department Seminar Series
Neurobiology Graduate Education Evaluation Committee
Biology Department Graduate Admissions
Genetics Curriculum Admissions
Biology Department Library Committee
Faculty Council Alternate
NIH Biomedical Research Grant Committee

Faculty Search, Biology
Faculty Search, Program in Molecular Biology & Biotechnology
University Honors Program (1993 - 1995)
Ph.D. Thesis Committees (51 students)
University Patent Committee (1994 -1997)
Department Computer Network Committee (Chair, 1994 -1997)

Committee Memberships at UW-Madison:

Molecular and Cellular Pharmacology Training Program (1997-2001)
Cell and Molecular Biology Training Program (1998-2001)
Examination and Oversight Committee (Chair, 1998-2001)
Molecular and Cellular Pharmacology Curriculum Committee (1999-2001)
Ph.D. Thesis Committees (three)
NASA SHARP Plus high school student mentoring (1999-2000)
Genetics/Biotechnology Building Addition Committee (2000-2001)
Masters in Biotechnology committee (2001)
Medical School Admissions (1999-2001)
Cardiovascular Training Grant Selection Committee (2001)
Drug Discovery & Development Training Program (2001)

Committee Memberships at ANL:

Space Committee (2001-present)
University of Chicago Cancer Research Center, Executive Committee (2002-present)
University of Chicago Biomedical Research Advisory Committee (2002-present)
Joint University of Chicago /ANL Faculty Search Committee (2002-2003)
Ph.D. Thesis Committees (three at UC; one at UIC)
Biosciences Division seminar chair, 2002-present
University of Chicago nominee for the 2006 Howard Hughes Medical Institute Professorship

Journal Reviewer:

Annual Reports in Combinatorial Chemistry and Molecular Diversity (Co-Editor; 1996-1998)
Biochemistry
Biophysical Journal
BioTechniques
Chemical Reviews
Chemistry and Biology
Combinatorial Chemistry and High-Throughput Screening (Associate Editor, 2002-present)
Development
Developmental Biology

Drug Discovery Today
EMBO Journal
Encyclopedia of Molecular Biology
European Journal of Biochemistry
FASEB J.
FEBS Letters
Gene
Immunotechnology
International Review of Cytology
Journal of Biological Chemistry
Journal of Cell Biology
Journal of Combinatorial Chemistry
Journal of Gene Medicine
Journal of Experimental Zoology
Journal of Molecular Biology
Molecular Biology of the Cell
Molecular and Cellular Biology
Molecular Diversity (Editorial Board; 1995-2003)
Molecular Reproduction and Development
National Science Foundation
Nature Biotechnology
Nature Materials
Nature Structural Biology
Nucleic Acids Research
Peptide Research
Proceedings of the National Academy of Sciences
Proteins: Structure, Function, and Genetics
Protein Engineering
Protein Expression, Design, and Selection
Protein Expression & Purification
Protein Science
Science

Study Sections:

NIH, Small Instrumentation Study Section, 1993-1994
NSF, Developmental Mechanisms Study Section, 1995-2000
NIEHS, *ad hoc*
US Army, *ad hoc*
Burroughs-Wellcome Trust, *ad hoc*
Telethon, *ad hoc*
Canadian Foundation for Innovation, *ad hoc*
DOE SBIR/STTR, *ad hoc*

Ph.D. Students:

Janice Perry Evans, 06/07/91, "Changes in the Cortical Cytoskeleton and Associate Membrane Proteins during the Oocyte-to-Egg Transition in *Xenopus laevis.*" Janice is presently an Assistant Professor at the Johns Hopkins University.

Bronwen Nishikawa, 01/31/92, "Neural Regulation of Calmodulin Gene Expression in *Xenopus* Leg Muscle." She currently works in Intellectual Property at KaroBio USA, Inc.

Ann Greig, 04/23/95, "Troponin T Isoforms in Rabbit and Human Hearts." Ann was a postdoctoral fellow at the University of Utah.

Thomas C. Ingledue, 08/22/95, "Subnuclear Localization of *Xenopus* hnRNP A1 and Identification of its Novel Nuclear Localization Signal." Tom is currently an instructor at Appalachian State University.

Andrew B. Sparks, 04/15/96, "Analysis of SH3 Domain-Ligand Interactions Using Combinatorial Peptide Libraries." Andrew is currently a staff scientist at Perlegen Sciences, Mountain View, CA.

Judy M. Thorn, 06/18/97, "Regulation of the Cortical Cytoskeleton in *Xenopus* Oocytes by Src." Judy is currently an Assistant Professor at Knox University, Illinois.

Heather H. Pierce, 06/18/97, "Molecular Recognition of Two Calcium-Binding Proteins, Calmodulin and Troponin C." Heather is currently a genetic counselor at the University of Kentucky (Lexington, KY).

Montarop Yamabhai, 11/19/99, "Molecular Recognition Properties of a New Protein Component of the Endocytic Machinery." Montarop is currently an Assistant Professor at the Suranaree University of Technology, Thailand.

Jeremy Kasanov, 11/10/00, "The Molecular Recognition Properties of WW domains". Jeremy is currently a post-doctoral fellow at Massachusetts General Hospital.

M.S. Students:

Yulia Hirschberg, 12/06/91, "Isoform Diversity of Rabbit Cardiac Troponin T Generated by Alternative Splicing." Yulia is presently a research associate at Ciba-Geigy in Tarrytown, New York.

Rong Guo, 04/24/96, "Defining the Protein-protein Interactions of Dystrophin," Physiology Department. Rong is currently a research associate at Duke University Medical Center.

Postdoctoral Fellows:

Lawrence M. Schwartz, 1987-1989; Ph.D. earned with Dr. Jim Truman, Department of Zoology, University of Washington, Seattle, WA. Lawrence is presently a Professor in the Department of Biology at the University of Massachusetts at Amherst.

Nils B. Adey, 1992-1995; Ph.D. earned with Dr. Clyde Hutchison, Department of Microbiology and Immunology, University of North Carolina at Chapel Hill. Nils is presently a staff scientist at Myriad Genetics in Salt Lake City, UT.

Norris Armstrong, 1993-1995; Ph.D. earned with Dr. David McClay, Department of Zoology, Duke University, Durham, NC. Norris is currently an Assistant Professor at the University of Georgia.

Alexei Kurakin, 1996-1999; Ph.D. earned at Moscow University, Russia. Alexei is presently a staff scientist at the Buck Center for Aging in Novato, CA.

Ece Karatan, 2002-present; Ph.D. earned at the University of Illinois, Urbana-Champaign. Ece will start as an Assistant Professor at Appalachian State University this summer.

Zhaozhong Han, 2002-present; Ph.D. earned at the Chinese Academy of Military Medical Sciences, Beijing, China. Zhaozhong is currently an Assistant Professor at Vanderbilt University.

Usham Kriplani, 2003-present; Ph.D. earned at the California Institute of Technology, Pasadena, CA.

John Kehoe, 2003-present; Ph.D. earned at University of California-Berkeley, Berkeley, CA.

Sabbatical Fellows:

Page A.W. Anderson, 1989; Professor, Duke University, Department of Pediatrics

Gabor Antony, 1990; Professor, Univ. New South Wales, Australia, Department of Pediatrics

Dave McClay, 1994; Professor, Duke University, Department of Zoology

Dana Fowlkes, 1994-1995; Cytogen Corporation, Princeton, NJ

Dr. Bobby Burkes, 2004-2005, Associate Professor, Grambling State University, Department of Chemistry

Undergraduates:

Barbara Page - Yale University, Biology Ph.D. Program
Ami Shah - UNC Medical School
Mark Renfro – University of Florida Medical School
Brian Smith - UNC Medical School
Anna Kantzer - Indiana University Medical School
Patrick Hurban - Univ. Utah, Biology Ph.D. Program
Kathy Dolocek - UNC Medical School
Michael Wade - UNC Genetics Ph.D. Program
Ahmad Ali - UNC Medical School
James Miller - Bowman Gray Medical School
Holly MacArthur - Univ. Florida Medical School
Ravi Sawhney - UNC Dental School
Laura Hinkle - UNC Medical School
Vickie Fowler - Duke University Medical School
Melissa Adams - Univ. California at Berkeley, Cell and Molecular Biology Ph.D. Program; NSF Fellowship
Jennifer Quirk - Duke University, Ph.D. Program
Tamara Caspary - Princeton University, Ph.D. Program
Katherine Mickey - Univ. Washington, Ph.D. Program
Nancy Schafstedde - UNC Medical School
Anthea Mataragnon - UNC Medical School
Colleen McClung – University of Virginia, Ph.D. Program
Marion Mull - Duke University Medical School
Noah Hoffman - M.D./Ph.D. candidate at UNC-CH
James Rider - UNC Medical School
Dimitri Laskoski – Princeton University, Ph.D. program
Emily Starr – currently enrolled at Stephens College
Erin Jezuit – currently a research associate at UNC-CH
Bridgit Banach – starting at Loyola University Medical School, M.D./Ph.D. Program
Claire Desmond – currently enrolled at University of Norte Dame
Justin Henry - currently enrolled at Grambling State University
April Kittel - currently enrolled at Grambling State University